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Preserving function and long-term patency of dialysis access

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Of the 283,932 patients with end stage renal disease (ESRD) receiving replacement therapy in the US in 1996, 62% were being treated with haemodialysis.[1] Improved survival of haemodialysis patients coupled with the inability to provide enough renal transplants for the growing ESRD population has resulted in an increase in the average length of time patients spend on dialysis. Vascular accesses are, therefore, required to function for longer periods of time. Maintenance of a reliable access to the circulation has been described as the Achilles' heel of modern haemodialysis.[2] Preserving access function and long-term patency are essential for efficient dialysis delivery.

Vascular access complications are the largest single cause of morbidity in the chronic haemodialysis population accounting for 15% of hospital admissions among US haemodialysis patients with an estimated cost of $150 million in 1990.[3] In some units, admission for vascular access related morbidity is as high as 30%.[4] The prevalence of dialysis treatments with delivered Kt/V (K = dialyser urea clearance, t = duration of dialysis, V = volume of distribution or total body water) less than 1.2 (inadequate dialysis) is about 28%.[5,6] Vascular access thrombosis and/or stenosis are the most common cause of haemodialysis access impairment or loss.[2,7–10] Uncorrected stenosis is associated with eventual AV graft thrombosis.[11] Before occlusion of access occurs, there is usually reduction of blood flow through it limiting inflow into the dialyser resulting in local recirculation. This, in turn, reduces effective solute clearance thereby decreasing the adequacy of treatment.

To reverse these trends, dialysis providers must take action to extend access use life by establishing protocols to monitor accesses at risk and audit programmes to ensure standards of care are being met. Regular access evaluation using methods such as routine physical examination, measurement of recirculation, venous dialysis pressure, dialysis adequacy tests, ultrasonic or radiological imaging combined with percutaneous or surgical interventions have been shown to prolong access life.[12] Furthermore, AV grafts revised electively have a more prolonged survival than grafts revised at the time of thrombosis.[13] The principal aim of any surveillance protocol should be to deploy simple and inexpensive, but sensitive and specific, methodology that can be applied easily by dialysis staff. Data on

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clinical parameters, dialysis adequacy and results of monitoring tests must be accurately documented and reviewed regularly for them to be useful.

Physical examination

Physical examination is an extremely useful method of screening for a failing access. History of prolonged bleeding following needle withdrawal, swelling in fistula arm or pain with dialysis point to access dysfunction. Alteration in the character of the palpable thrill or conversion of a thrill to a pulse indicates stenosis. Due to increased velocity over a stenotic area, a localised increase in the pitch of the bruit suggests stenosis.

Access patency

Access patency can be assessed by measurement of the pressure in the venous return line of the dialyser circuit. When monitored regularly using standardised protocol, dynamic venous pressure (DVP) provides a sensitive and cost effective method of detecting access stenosis.[14] If the DVP exceeds 150 mmHg on three consecutive dialysis sessions, fistulography is recommended. Although static dialysis pressure (venous dialysis pressure at zero blood flow) is thought to be more strongly predictive of outflow stenosis than dynamic pressure measurements, extra equipment is required for its measurement.

Access recirculation

Access recirculation is the immediate return of venous (dialysed) blood to the dialyser, effectively short-circuiting the patient. Several methods exist for measuring recirculation: urea dilution method, urea modelling, thermal dilution, ultrasound dilution, optical density and bedside occlusion/pressure measurements.[12,15] Experience with monthly recirculation studies and the performance of fistulography in patients with consistently high levels (> 15%) has shown that elevated recirculation ratios correctly identify patients with significant venous stenosis.[16] Urea recirculation ratios however, depend on factors such as needle placement, extracorporeal blood flow, hypotension, decreased cardiac output, intravascular volume depletion, venous stenosis and arterial stenosis making it non specific for detecting access dysfunction.[2]

Delivered dialysis dose

The most commonly used methods of calculating dialysis delivery are based on urea kinetic measurements. Kt/V provides a simple mathematical quantitation of dialysis,[17] but may not reflect the real dose of dialysis delivered. A better method for determining delivered dialysis dose, the solute removal index (SRI urea), is calculated using the formula:

$$SRI = Vd \times Cd \times 100/Vo \times Co \qquad \text{Eq. 1}$$

where, Vd = volume dialysate effluent, Cd = urea level in dialysate effluent, Vo = total body water before dialysis and Co = blood urea before dialysis.

Currently, dialysis is planned to achieve a minimum Kt/V of 1.2. The optimum Kt/V is 1.4 (SRI 80%) for non-diabetics and 1.6 (SRI 85%) for diabetic patients.[18] Irrespective of the method used in calculating the delivered dose of dialysis, unexplained decreases in their value must raise suspicion about access dysfunction.

Colour flow Doppler ultrasonography

The use of colour flow Doppler ultrasonography in predicting haemodialysis access flow is rapidly gaining ground.[19,20] This technique is non-invasive, painless, portable and, in expert hands, reproducible. While its ability to detect or predict prosthetic grafts at risk of stenosis is proven, its role with native AV fistulas is still under investigation.[20] Gadallah *et al.*,[21] in a comparative study, showed close correlation between Doppler ultrasound and fistulography in diagnosing anatomic stenosis, thus enhancing its role as a screening test. Interventional magnetic imaging is a rapidly developing field that may provide outpatient assessment of problematic access in the future. Interventional radiologists are increasingly called upon to evaluate and treat failing vascular accesses.

Angiography

Routine angiography screening of all accesses is uneconomical and not practicable. Using clinical and quality assurance parameters as indications for performing fistulography, Schwab and co-workers demonstrated improved longevity of access sites and a 3-fold decrease in thrombosis.[14] Using a slightly different surveillance protocol, Cayco *et al.*[22] reported a 41% decrease in thrombosis rate in patients with AV grafts. There is no doubt that the way forward is regular monitoring of accesses with the aim of early detection of dysfunction and prompt intervention to preserve or salvage the access. With the application of all or some of these screening tests, prediction of the majority of imminent access failure will become possible. The next step

is to translate this 'early warning sign' into action (Fig. 1) that would prevent access failure and prolong its useful life. Angioplasty or surgical revision of a stenotic lesion increases the lifetime of a vascular access.[7,13] To this end, all significant stenosis (>50%) detected should be corrected by angioplasty or surgical revision before actual fistula failure. Adoption of such a protocol will result in fewer access related hospitalisation, lower access replacement rates and improved access survival.[14,16] Radiological interventions do not require general anaesthesia and can be repeated. The role of stenting of recurrent stenosis needs to be studied further.

Fistula infection

Fistula infection accounts for about 20% of fistula complications and is the second leading cause of fistula failure.[10] Considering how frequently AV fistula or grafts are cannulated, it is surprising that this complication is not more common. Fistula infection, when it occurs, has a devastating effect on vascular access. It is usually due to a breakdown in aseptic techniques and can often be traced to dialysis staff.[2] Bacteraemia should be treated as a quality assurance issue. Any individual staff associated with a high incidence should be identified and retrained.

Access complications

It is common knowledge that while some patients are prone to developing thrombosis, stenosis or other access complications, others seem resistant to them. Multiple factors are involved in access complications. Analysis of these factors may allow the selection of the most appropriate access procedure for individual patients.[9] The native AV fistula is still considered as the optimum access modality for most ESRD patients. Primary AV fistulae have low morbidity, excellent patency rates when matured and improved performance over time with low complication rates.[2,7,23] To increase the proportion of patients having AV fistulae, education of physicians and patients about preservation of potential access sites and early referral to the nephrologist are required. But not all ESRD patients are suitable for AV fistula. Such factors as small vessels,[24] diabetes mellitus, black race, age >64 years,[25] patients with hypercoagulable states, erythropoietin,[26,27] have been found to increase the risk of vascular access thrombosis. Patients with frequent episodes of access failure need to be investigated for any behavioural characteristics that may be responsible. Patients and their care-givers should be educated

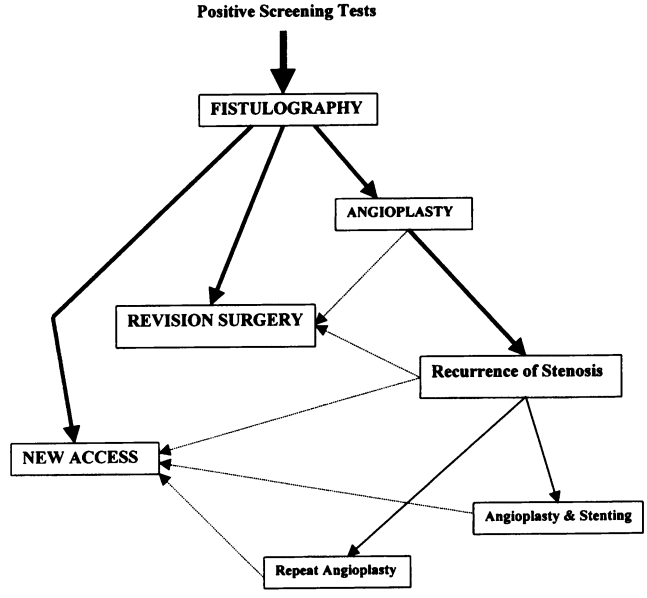

Figure 1 Management of the failing AV fistula / graft

about simple emergency procedures and basic care of the access. This must include immediate reporting of any symptoms and sign of infection or absence of bruit to dialysis personnel.

Antiplatelet drugs

There is evidence to suggest that antiplatelet drugs are effective in preventing early AV fistula or graft thrombosis.[28–30] Contrary to popular belief, low dose aspirin did not have as beneficial effect as dipyridamole and may, in fact, worsen the risk of intimal hyperplasia in patients with AV grafts.[29] There is, therefore, a need for a multicentre collaborative study to determine the usefulness or otherwise of antiplatelet agents in preventing thrombosis / stenosis of AV fistula or grafts.

The future

In future, the volume of patients requiring vascular access for dialysis will undoubtedly increase. The proportion of elderly patients with peripheral vascular disease and other co-morbid factors will also increase. So will the number of long-term dialysis patients who have exhausted all sites for both primary and secondary vascular access procedures. This will happen in the face of dwindling organ donor resources. The lessons of the past must challenge us to formulate carefully considered clinical practice guidelines for dialysis access

provision in the future. To combat this problem as we approach the new millennium, action is required on several fronts: (i) patient evaluation prior to access placement; (ii) choice of appropriate access modality; (iii) monitoring and maintenance; (iv) prevention of infection (v) timing of intervention for access complications; (vi) optimal approaches for treating complications; and (vii) potential quality of care standards.[31]

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